Evolution, Ecosystem Pathways, Rivers, Eternity, and the Sea …Are Diadromous Species a Forgotten Vital Link?

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Linking Hydrological Change and Ecological Response in Streams and Rivers of the Eastern United States

An Eastern Regional Workshop

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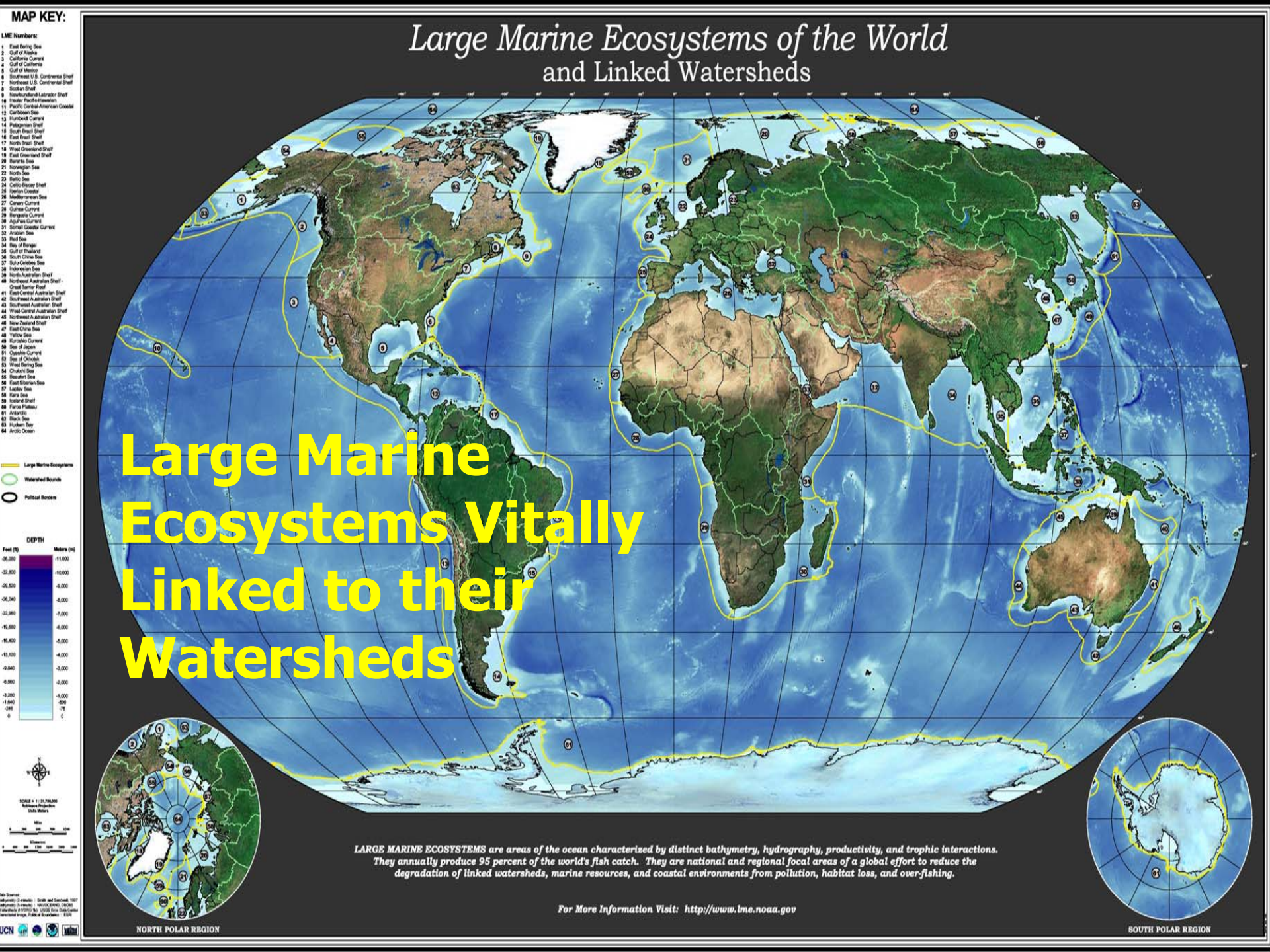
Roanoke River

Weldon Shoals


MAP KEY:
LME Numbers:
1 East Bering Sea
2 Gulf of Alaska
3 California Current
4 Gulf of California
5 Gulf of Mexico
6 Southeast U.S. Continental Shelf
7 Northeast U.S. Continental Shelf
8 Scotian Shelf
9 Newfoundland-Labrador Shelf
10 Insular Pacific-Hawaiian
11 Pacific Central-American Coastal
12 Caribbean Sea
13 Humboldt Current
14 Patagonian Shelf
15 South Brazil Shelf
16 East Brazil Shelf
17 North Brazil Shelf
18 West Greenland Shelf
19 East Greenland Shelf
20 Barents Sea
21 Norwegian Sea
22 North Sea
23 Baltic Sea
24 Celtic-Biscay Shelf
25 Iberian Coastal
26 Mediterranean Sea
27 Canary Current
28 Guinea Current
29 Benguela Current
30 Agulhas Current
31 Somali Coastal Current
32 Arabian Sea
33 Red Sea
34 Bay of Bengal
35 Gulf of Thailand
36 South China Sea
37 Sulu-Celebes Sea
38 Indonesian Sea
39 North Australian Shelf
40 Northeast Australian Shelf - Great Barrier Reef
41 East-Central Australian Shelf
42 Southeast Australian Shelf
43 Southwest Australian Shelf
44 West-Central Australian Shelf
45 Northwest Australian Shelf
46 New Zealand Shelf
47 East China Sea
48 Yellow Sea
49 Kuroshio Current
50 Sea of Japan
51 Oyashio Current
52 Sea of Okhotsk
53 West Bering Sea
54 Chukchi Sea
55 Beaufort Sea
56 East Siberian Sea
57 Laptev Sea
58 Kara Sea
59 Iceland Shelf
60 Faroe Plateau
61 Antarctic
62 Black Sea
63 Hudson Bay
64 Arctic Ocean
Large Marine Ecosystems
Watershed Bounds
Political Borders
DEPTH
Feet (ft)
Meters (m)
Large Marine Ecosystems of the World
and Linked Watersheds
Large Marine Ecosystems Vitally Linked to their Watersheds
LARGE MARINE ECOSYSTEMS are areas of the ocean characterized by distinct bathymetry, hydrography, productivity, and trophic interactions. They annually produce 95 percent of the world's fish catch. They are national and regional focal areas of a global effort to reduce the degradation of linked watersheds, marine resources, and coastal environments from pollution, habitat loss, and over-fishing.
For More Information Visit: http://www.lme.noaa.gov
NORTH POLAR REGION
SOUTH POLAR REGION

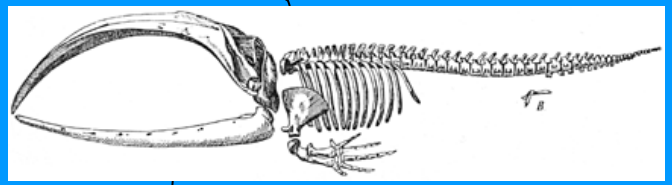
River Basins: Eternal Stairsteps for Evolution and Speciation

- Diverse and evolving habitats
- Vital connectivity between land and sea
- Vital channels for global biogeochemical cycles

Weldon Falls, Roanoke River

Ancient River Basin

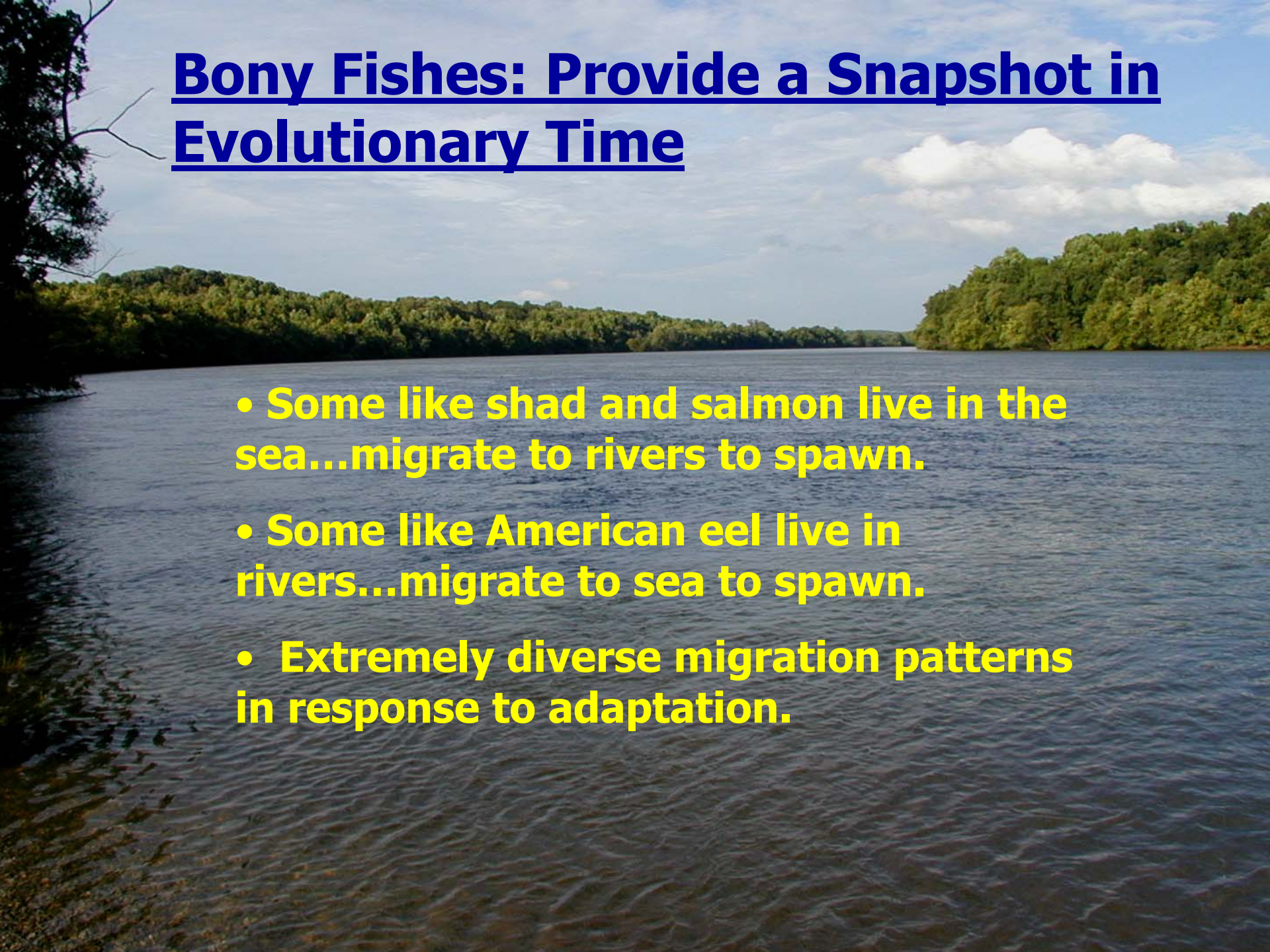
Rivers as pathways for evolution: familiar examples



- Life began in the Sea – then moved to land…
- Whales: evolved from land back to sea…
- Bony fishes: evolved from land to river to sea, and back again…Silurian period…25,000 species originated

OCEAN

Bony Fishes: Provide a Snapshot in Evolutionary Time



- Some like shad and salmon live in the sea…migrate to rivers to spawn.
- Some like American eel live in rivers…migrate to sea to spawn.
- Extremely diverse migration patterns in response to adaptation.

Diadromous Species Atlantic Coast

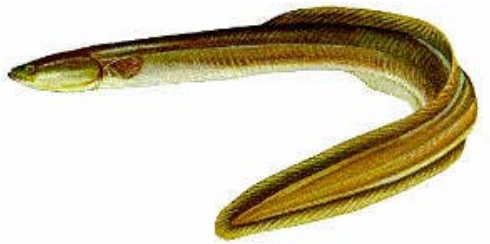
American shad

Atlantic sturgeon

Blueback herring

Shortnose sturgeon

Striped bass



American eel

River Migration of Shad

Diadromous Fishes: Ocean Migrations of Shad and Blueback Herring

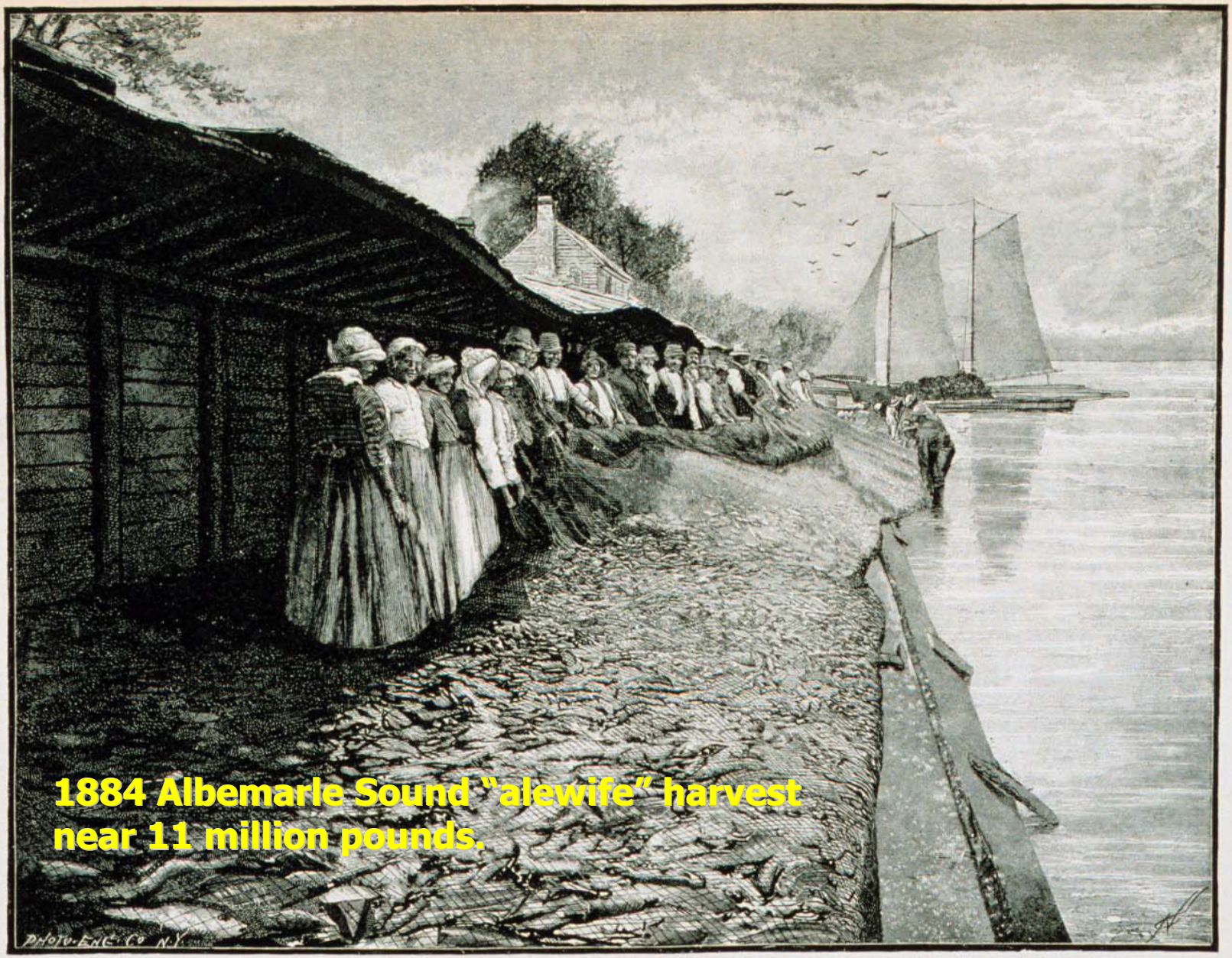
- Vital riverine-marine ecological link
- Link in evolutionary continuum
- Global implications for marine fisheries

Diadromous species such as herring and shad …

An unexplored vital link between watersheds and marine ecosystems…

How significant is this linkage?

Outmigrating river herring, Chesapeake



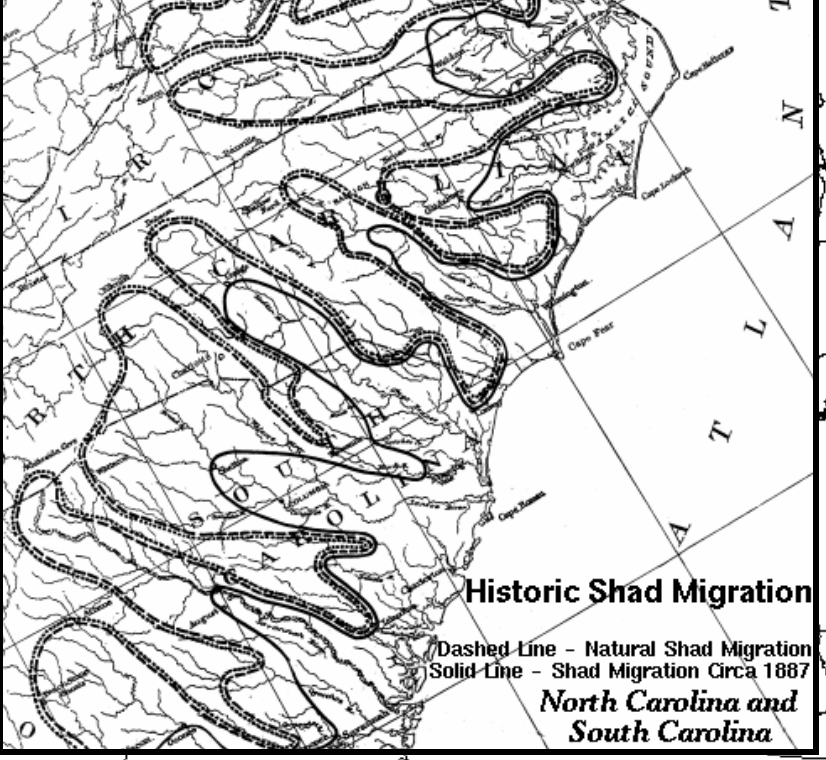
THE RIVER FISHERIES OF THE ATLANTIC STATES.

Haul-seine fishing at Sutton Beach, Albemarle Sound, North Carolina: a large haul of alewives. (Sect. v. vol. i, p. 636.)

From a photograph.

Examining the Atlantic Coast Shad/herring link…

1. Large river basins of the Atlantic each must have had spawning runs well over 10 million prior to dams, shad and herring alone.
2. Coast-wide runs may have been in hundreds of millions.
3. Spawning runs and outmigrating YOY must have been highly significant in terms of biomass interchange between riverine and marine ecosystems.
4. Intuitively large magnitude biomass linkage…worth exploring.



Historic Spawning Grouds of American Shad

90 0 90 180 270 Miles

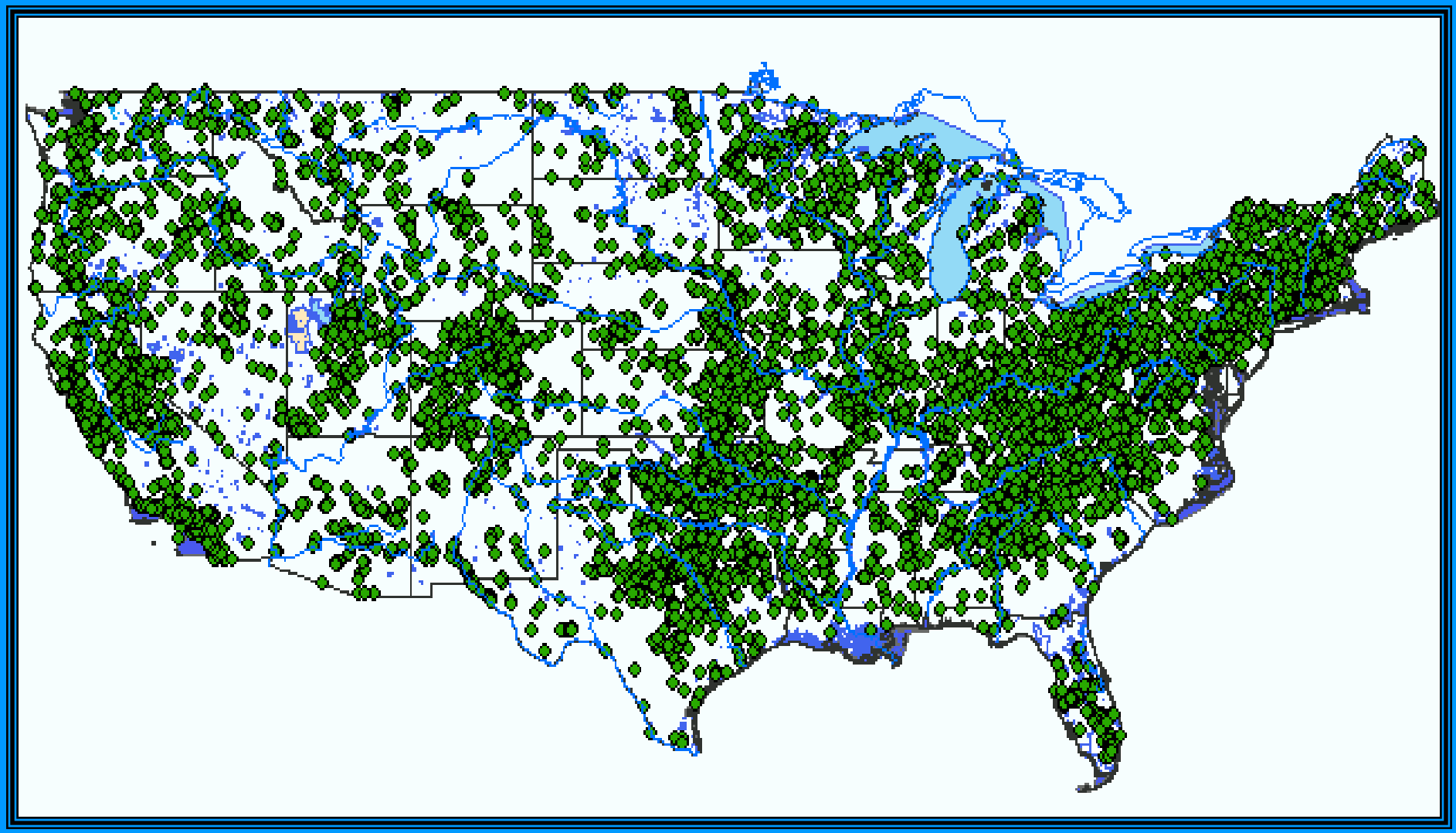
N

Atlantic Coast Potential Original Spawning Run Size

American shad and river herring

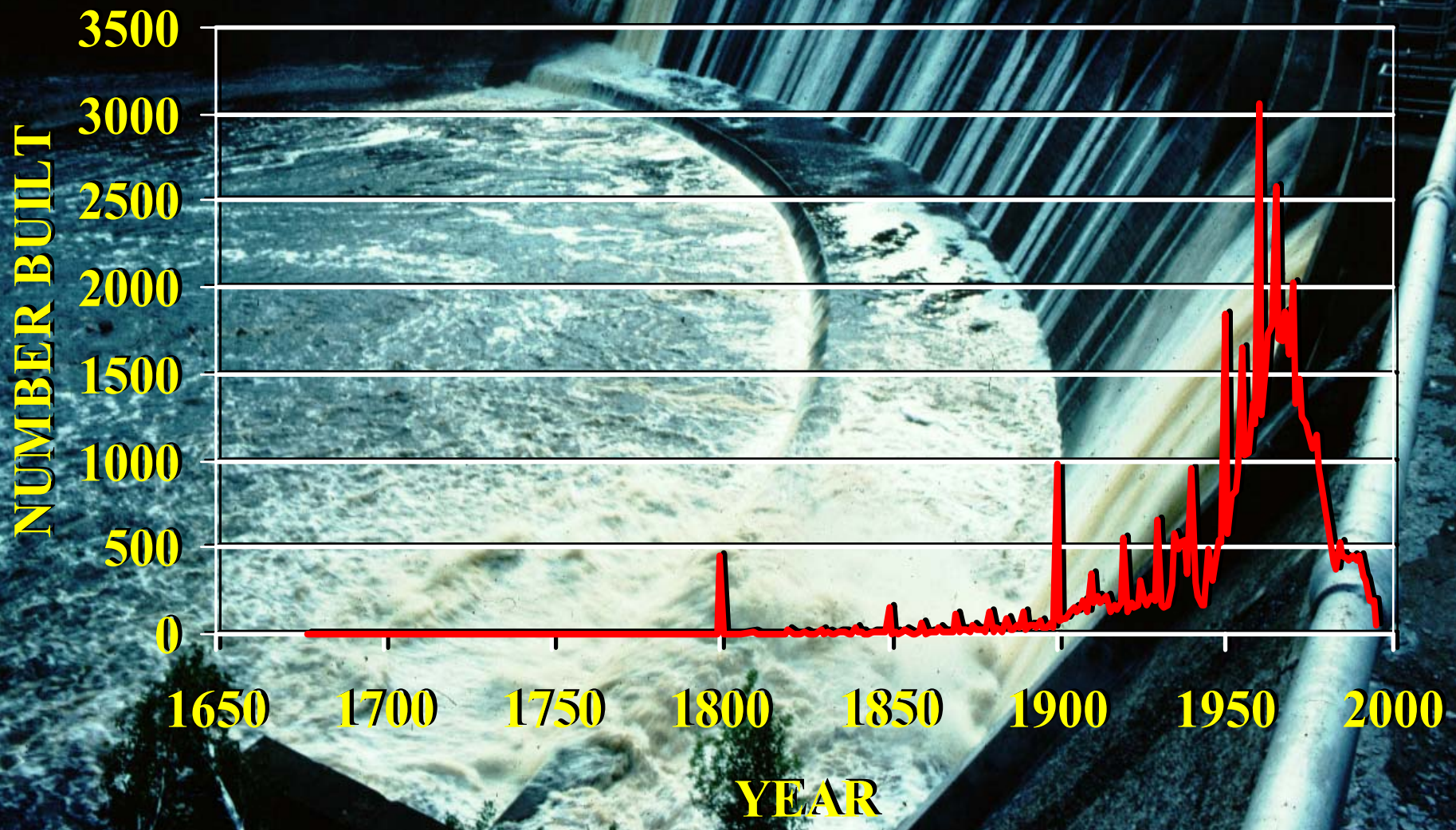
Total habitat Area:	1,171,400 ha
Estimated shad spawning run size	144,700,000 “fish”
Estimated herring run size	1,446,672,980 “fish”
Shad biomass estimate	188,110,000 kg
Herring biomass estimate	312,481,360 kg
Total	500,591,360 kg

Major Dams in the US



DAM CONSTRUCTION IN THE U.S.

Source: Aadland, 2004



Significance of Atlantic Coast Dams?

Busch, et al. 1998

- **15,515 dams, Maine to Florida**
- **84% of historic river habitat blocked**
- **77% blocked, NC to FL**

Augusta Diversion Dam, Savannah River (1840)

The Age of Human Ingenuity: Damming the Rivers

- Disruption of river pathways for evolution and speciation
- Global alteration of biogeochemical cycles
- Global change in river processes
- Global magnitude of change essentially unnoticed by human cultures, unprecedented in geological time

Specific Impacts of Altered Hydrology …beyond the range of evolutionary adaptation

- **Habitat impacts**
  - **I.e. to gravel beds, riffle/pool sequences, riparian vegetation**
- **Impacts to diadromous fish**
  - **Changes in flow**
  - **Thermal changes**
  - **Loss/degradation of habitat**
  - **Increased predation**

Research Needs Suggested by NOAA Fisheries

Atlantic Coast Rivers

1. Determination of important habitat/life history needs for key diadromous species & early life stages
   - Shortnose, Atlantic sturgeon spawning and Maturation.
   - American shad spawning and maturation.
   - American eel maturation.
2. The relationship among habitats and need for connectivity within river basins, all diadromous species.
3. Safe/Effective Upstream and Downstream Passage for Atlantic and shortnose sturgeon.

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Research Needs Suggested by NOAA Fisheries

Atlantic Coast Rivers

4. Clarifying the ecological linkage among river ecosystems, diadromous species, and marine ecosystems, including managed marine fisheries.
5. Clarifying behavioral and ontogenetic characteristics of diadromous species, particularly shortnose and Atlantic sturgeon.
6. Further clarifying the genetic status of diadromous species of management interest in Atlantic River Basins.

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Research Needs Suggested by NOAA Fisheries

Atlantic Coast Rivers

7. Clarify interspecies relationships concerning diadromous species, other riverine species
   - e. g. shad predator-prey
   - Bald eagle-diadromous fish
   - Riverine fishes, e.g. robust redhorse, others
8. Biosynchrony? Wetlands> allochthonous carbon> zooplankton>shad larvae

Summary: there are many linkages to explore in rivers.

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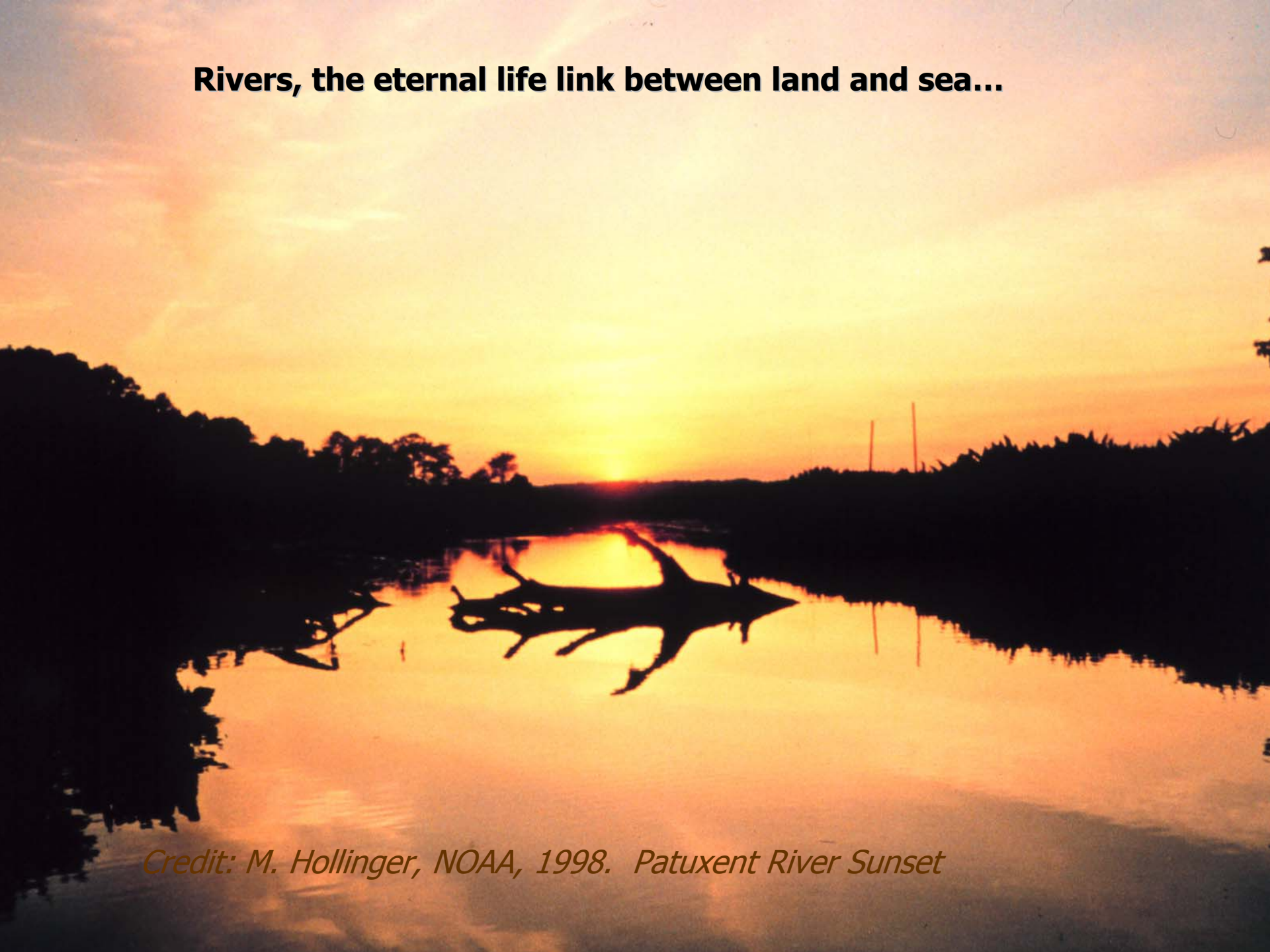
Rivers, the eternal life link between land and sea…



Credit: M. Hollinger, NOAA, 1998. Patuxent River Sunset